Bachelor of Science, Major in Physics for Modern Technology
External Review Report

November 30 & December 1, 2022

External Review Team Members

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OVERALL ASSESSMENT OF THE SELF-STUDY REPORT

Criteria: The Self-Study Report provides a data-supported analysis of the program's strengths, weaknesses, opportunities and challenges.

Standard for Assessing the Report:

- Strengths and areas of improvement identified in the report are supported by data and external review findings.
- Recommendations are supported by data, a clear rationale, and external review findings.

The External Reviewers:

☒Validate the Self-Study Report's findings and recommendations

☐Do not validate the Self-Study Report's findings and recommendations

Rationale for this Determination:

- This report represents the findings of the External Review Team (ERT) charged with reviewing the Bachelor of Science in Physics for Modern Technology offered by the Physics Department at Kwantlen Polytechnic University.
- Prior to the review, the ERT was provided with a self-study document produced by the Physics Department, supported by data in an appendix, as well as documents with further information on KPU, such as library resources and general education requirements.
- The review ERT met with the Department Chair, Dean of the Faculty of Science and Horticulture, Physics faculty, current students, alumni, advisors, liaison librarians, and industry professionals on the Program Advisory Committee (PAC) in a blend of in-person and online meetings.
- Overall, the ERT formed a very positive impression of the PMT program. The ERT validates the self-study as detailed and accurate documentation of the strengths of the program as well as areas identified for improvement.
- In particular, the strengths of the PMT program are as follows:
    - It is seemingly unique in North America as an applied physics degree that is intensely focused on hands-on experiential learning with the goal of placing graduates into careers in the technology sector (Chapter 2).
    - This focus on career training is strongly aligned with the mission of KPU as a polytechnic university.
    - PMT graduates have had an impressive 100% success rate in transitioning to the next step of their careers, including employment in optics, software, automation and other industries and also further training in post-graduate schooling in physics, engineering, and business (Chapter 3).
    - The ERT found the faculty involved in the program to be strongly engaged in the success of the PMT program and of the students in it (Chapter 4). They are all trained physicists who have maintained currency in current experimental physics knowledge and skills. The methods of instruction – particularly the focus on experiential learning and "studio-style" combined lecture/lab courses – are modern and appropriate for the program goals.
    - Everyone the ERT met with was extremely supportive of the PMT program and appreciative of its goals, and these sentiments were especially strong in alumni and current students.

- The self-study report also identified areas for improvement, which the ERT agrees with. These areas include the following.
    - The key challenge for the PMT program is recruitment and retention of students. It is difficult to separate the effects of the COVID pandemic, particularly on a program as focused on experiential learning as the PMT program. However, this is a challenge for Physics programs at many universities, and it must be faced for the PMT program to thrive. This [self-study] report contains several recommendations (Chapter 3), but there is a clear need for dedicated recruiting and outreach support in conjunction with upper administrative levels within the Faculty of Science and Horticulture and KPU. There may be a need source additional funding and support for this department.
    - This ERT was also tasked with reviewing the PMT program curriculum. Though a well-designed program, the ERT has several recommendations to offer (Chapter 2), particularly in the ancillary areas of programming, business, biology, and communication skills. Rather than a weakness, per se, the ERT considers their recommendations to be in line with standard ongoing modifications that all programs make to their curriculum over time.
    - Another key challenge for the PMT program relates to available space (Chapter 5). The ERT notes that the recent loss of dedicated project space limits what projects and hands-on activities can be undertaken by students due to the need to flexibly share space. While space is always at a premium in universities, and programs must demonstrate a need for space through significant enrollments, the PMT program also cannot achieve its goals without dedicated project space. The ERT encourages finding such a dedicated space for the PMT program and the programs growth while continuing the continued flexible use of space by the department for lectures, labs, and projects. This would benefit recruitment, retention, and overall visibility of the Program, such as the other programs at KPU.

REVIEWERS' VALIDATION OF THE SELF-STUDY REPORT CHAPTERS

CHAPTER 2: Curriculum Review

Criteria: This chapter provides a clear profile of the program graduates, relevant program learning outcomes, and a curriculum mapping assessment that adequately identifies any gaps in the program's curriculum. The assessment is supported by appropriate evidence and conclusions.

Standard for Assessing this Chapter:

- Strengths and areas of improvement identified in this chapter are supported by data and external review findings.
- Recommendations in this chapter are supported by data, a clear rationale, and external review findings.

The External Reviewers:

☒Validate the Self-Study Report's findings and recommendations

☐Do not validate the Self-Study Report's findings and recommendations

Rationale for this Determination:

1. Program learning outcomes are well-defined. Core theoretical physics knowledge (e.g. mechanics, electricity and magnetism, quantum mechanics), hands-on technical skills (test and measurement equipment, electronics, DAQ devices and microcontrollers), and specialized applications (e.g. sensors, optics, actuators) are all scaffolded throughout the curriculum.
2. A key strength of the program curriculum is the project-based learning, which culminates in a 4th-year project. This capstone project gives students experience in planning, designing, and executing a hands-on physics project targeted at real-world applications, which is invaluable experience for technological careers.
3. Work experience in industry and research labs provides "real-world" experience, networking, and helps students explore interests.
4. Inclusion of Business courses in the curriculum is seen as an asset, especially by alumni and PAC members from industry. Currently the main constraint on Business courses to be counted towards the degree is that they may not be math-heavy courses for Business students, as PMT students already receive sufficient quantitative training. (**Curriculum Recommendation #1**)
5. Another key skill identified by the self-study report, PAC, and alumni is computer programming and the self-study provides several suitable recommendations. It was noted that many Physics students and faculty are largely self-taught and do not always follow best practices. (**Curriculum Recommendation #2 & Curriculum Recommendation #3**)
6. The ERT was asked to consider the biology component to the curriculum. Similar to business skills, a small number of courses (a single course even) is insufficient to train students in any depth in a subject area. However, the ERT, guided by the PAC, sees value in exposure. The fluency in the field of biology gained from an introductory survey course is helpful in preparing PMT graduates to work alongside biologists and health scientists in biotech and medical physics careers. Such cross-literacy is an extremely important skill in working with diverse teams. It should be noted that the biology course component is required as part of the degree framework.

7. Students and PAC members alike saw significant value in the work term, but one challenge that was identified was the length of the work term: 4-month vs. 8-month vs. multiple 4-month terms. Students and alumni expressed a desire for more 4-month terms, to allow exploration of different fields and types of career paths. Some PAC members acknowledged that longer work terms become an immediate asset to companies, rather than functioning largely as training and recruitment activities. The ERT is sympathetic to both points-of-view, but also acknowledges the finite room in a program for different activities and the desire to keep completion times down. (**Curriculum Recommendation #4**)
8. The quality of the connection to the Lower Mainland technology sector is another key strength of the Program. The self-study report identifies a few subject areas that are relevant to modern technology and may be suitable for inclusion in the program in some capacity. The PAC also provided constructive suggestions during consultation with the ERT. (**Curriculum Recommendation #5**)

Additional recommendations, if any, identified by the ERT— include a rationale for each recommendation:

Curriculum Recommendation #1: Constrain the choice of Business courses to areas identified by the PAC as being key – give students fluency in Business language and processes, an overview of how companies are structured and work, and an understanding of issues involved in making business decisions about the viability of products and services, and overall project management skills. A suggestion is to incorporate business skills into Physics project courses through a focus on project management in conjunction with the project-based learning already in the program to gain experience in planning around design-of-experiment, de-risking, strategic planning, etc. Such an approach could provide a unique value for physics graduates.

Curriculum Recommendation #2: The ERT encourages the Department to see if a formal programming course can be added to the curriculum. Exposure to best practices in programming is valuable. At the very least students should be made aware of best practices and methods and tools for collaborative programming projects, version control, documentation, data handling, and other skills that are common in many tech jobs.

Curriculum Recommendation #3: Beyond formal programming, the ERT recommends continued inclusion of computing throughout the PMT curriculum and encourages a top-down scaffolded approach to skills used in PMT courses, with a focus on modern scientific languages such as Python.

Curriculum Recommendation #4: The ERT recommends that the department investigate whether additional flexibility can be added to the PMT program to allow multiple work terms, possibly in successive summer terms, or even to include longer terms within a year. As enrolment increases, the administrative workload of placing students in work terms will grow, particularly if more work terms are included in the program. The ERT encourages the Department to seek administrative support (such as university support for co-op experiences, or integration with the KPUs Co-operative Education infrastructure) as needed.

Curriculum Recommendation #5: Incorporate technology being developed in the greater Vancouver area into the curriculum via course material, laboratory projects, industrial seminars, and tours. The program should continue to leverage and expand the scope of these industry connections to market itself internally and externally.

CHAPTER 3: Program Relevance and Student Demand

Criteria: This chapter adequately assesses program's relevance, faculty qualifications and currency, connections to the discipline/sector, and student demand. The assessment is supported by appropriate evidence and conclusions.

Standard for Assessing this Chapter:

- Strengths and areas of improvement identified in this chapter are supported by data and external review findings.
- Recommendations in this chapter are supported by data, a clear rationale, and external review findings.

The External Reviewers:

☒Validate the Self-Study Report's findings and recommendations

☐Do not validate the Self-Study Report's findings and recommendations

Rationale for this Determination:

1. There seems to be a high demand for graduates of PMT, evinced by 100% job placement. The ERT meeting with the PAC and program alumni highlighted this fact. Alumni spoke positively about how the program prepared them for their chosen career paths; many of whom chose to continue working with industrial partners or labs that they partnered with for the work experience elements of the program. Feedback from employers was that the students that they had worked with were well-prepared and provided many constructive suggestions for curriculum improvements as part of this Program Review.
2. Students go on to tech careers, business careers, or further advanced degrees (MSc in physics or engineering, MBA) as evidenced by the ERT discussions with alumni and survey results in the self-study appendices.
3. The PMT Program is well aligned with KPU's mission as a polytechnic university with a strong emphasis on vocational training.
4. The key challenge identified for the Program is that of recruiting and retention (**Program Demand Recommendations #1-4)**.
    - The ERT notes several positive recommendations in the self-study report regarding addressing known issues with diversity and inclusivity within physics and the under-representation of different communities and indigenization. and supports these recommendations. These are well in-line with a modern approach to education.

Additional recommendations, if any, identified by the ERT— include a rationale for each recommendation:

Program Demand Recommendation #1: The ERT encourages KPU to provide the PMT program with dedicated recruiting and outreach support that understands the program, target audience, and careers. One of the key roadblocks to increasing enrolment is getting information to prospective students, their teachers, and parents. Existing university resources and connections with prospective student populations can be leveraged to increase program visibility, but these resources must be coupled with deep knowledge of the outcomes of the Program and career opportunities for Program graduates. The ERT considers this one of the most important recommendations in this Review.

Program Demand Recommendation #2: Use KPU resources (such as the marketing division or perhaps a journalism co-op student) to create promotional materials for the PMT program. In particular, the ERT suggests focusing on careers, as many students and parents do not know what sort of careers can be pursued with an applied physics degree. Students and alumni that the ERT met were enthusiastic and articulate about the PMT program and their careers: feature these students and alumni in these materials as inviting case studies.

Program Demand Recommendation #3: Many students take introductory Physics courses at KPU intending to, e.g., obtain Engineering certificates and transfer to a different school. The PMT program shares many features with Engineering programs but offers significant flexibility on careers and training. Consider ways to attract/retain students from these paths. This is an opportunity for additional cross-functional collaboration with PMT Program and FSH advising services.

Program Demand Recommendation #4: Seek opportunities to leverage the experiential learning of the students to participate in high-profile postsecondary student competitions (Formula SAE, as a representative example) to raise the external profile of the Program. Many competitions include funding and in-kind contributions from industry partnerships.

CHAPTER 4: Effectiveness of Instructional Delivery

Criteria: This chapter adequately examines the effectiveness of the instructional design and delivery of the program and student success. The assessment is supported by appropriate evidence and conclusions.

Standard for Assessing this Chapter:

- Strengths and areas of improvement identified in this chapter are supported by data and external review findings.
- Recommendations in this chapter are supported by data, a clear rationale, and external review findings.

The External Reviewers:

☒ Validate the Self-Study Report's findings and recommendations

☐Do not validate the Self-Study Report's findings and recommendations

Rationale for this Determination:

1. The faculty are all highly trained physicists. Faculty currency is maintained through engagement in literature, professional organizations, physics conferences, and research involvement.
2. Experiential learning is at the forefront of the PMT program. Such active learning is well in-line with best educational practices. (**Instructional Delivery Recommendation #1)**
3. Many courses are taught in a combined lab-lecture format, a so-called studio format, that promotes active learning and learning-by-inquiry. The ability to offer this type of learning is an advantage of the PMT program.
4. The ERT observed faculty and instructional staff working one-on-one with students involved in complicated independent projects. Such mentoring is effective at demonstrating best practices in the hard-to-teach area of experimentation.
5. The KPU Physics Departments uses a number of innovative practices and outreach efforts, such as the CloudLab for performing remote physics experiments and demonstrations. Several universities across Canada have also taken advantage of this resource offered. (**Instructional Delivery Recommendation #2**)

Additional recommendations, if any, identified by the ERT—include a rationale for each recommendation:

Instructional Delivery Recommendation #1: Though somewhat beyond the scope of review of the PMT program, the ERT learned of administrative scheduling difficulties in the multiple streams of introductory physics courses (life-science, engineering, etc.) combining into the same lab courses. The Physics Department should examine the administrative structure of its introductory courses, particularly the lab courses, and streamline them where possible. Also, beyond the scope of the review, some of the ERT encourage the Physics Department to consult recent literature on the purpose and use of introductory physics labs when considering their lab courses, as recent Physics Education studies have much to say about what sort of learning goals are most effective in lab environments.

Instructional Delivery Recommendation #2: We encourage KPU to continue supporting the high visibility CloudLab program with dedicated infrastructure to continue offering it. We also recommend a stronger Physics Department branding of the CloudLab infrastructure to leverage it in recruiting efforts. The ERT team recommends that the PMT program continue to work with KPU to encourage the dedicated space allotment needed for the program for not only visibility but viability and growth.

CHAPTER 5: Resources, Services and Facilities

Criteria: This chapter adequately assesses program's resources, services, and facilities from both the student and faculty perspective. The assessment is supported by appropriate evidence and conclusions.

Standard for Assessing this Chapter:

- Strengths and areas of improvement identified in this chapter are supported by data and external review findings.
- Recommendations in this chapter are supported by data, a clear rationale, and external review findings.

The External Reviewers:

☒Validate the Self-Study Report's findings and recommendations

☐Do not validate the Self-Study Report's findings and recommendations

Rationale for this Determination:

1. Space: The ERT commends the use of space for the PMT program, scheduling lectures, labs, and project courses in the same space. However, this flexibility also limits the type and extent of projects that PMT students can participate in. This space usage is in part due to the recent loss of dedicated project space. (**Facilities & Services Recommendation #1)**
2. Equipment: The PMT program is well-stocked with standard laboratory teaching and measurement equipment, and the PMT program has leveraged in-kind donations of research-grade scientific instruments from industrial partners. These specialized pieces of equipment give students excellent training and experience with modern scientific technology. (**Facilities & Services Recommendation #2)**
3. Software: The report identifies software as an area of improvement that should be explored; however, student satisfaction in this area is quite high while faculty satisfaction is middling. (**Facilities & Services Recommendation #3)**
4. Library Services: The Self-Study report acknowledges that the usage of library and advisory services are low among students; however, satisfaction is high among those that do use those services. From ERT discussions, it was clear that some initiatives (such as the full-semester borrowing of curated lab-work kits for home use) were very successful and could be expanded and leveraged in the future. The self-study report also identifies some clear opportunities for increasing engagement with available Library services.
5. Advising Services: The self-study report suggests that advising services are underutilized and that satisfaction is low among faculty while high among students and alumni. Several additional challenges were identified during ERT conversations including career trajectories and coursework requirements for further study or graduate school. (**Facilities & Services Recommendation #4)**

Additional recommendations, if any, identified by the ERT—include a rationale for each recommendation:

Facilities & Services Recommendation #1: Dedicated project space should be found for PMT students. The ERT recognizes that such space must be supported by higher enrollments in the Program; however, the program will have challenges growing from its current size without this space. The ERT team also recognizes that there are other small specialized programs at KPU that have dedicated project space, labs, and equipment. This has given these programs not only visibility, but room for growth both in enrollment and the program. The ERT recommends that the PMT look and some of the best practices/strategies that other programs have used.

Facilities & Services Recommendation #2: We encourage the PMT program to continue to seek industrial partnerships and for KPU to continue to support the acquisition, installation, and operation of this high-tech equipment. The engagement with the current PAC is well established, but further membership may be a place to explore for options of industry-based projects, support, student mentorship for capstone, and sponsorships for awards and competition entries for students and projects.

Facilities & Services Recommendation #3: Though the ERT did not explore this in detail during meetings with faculty and students. The program should explore whether additional software resources are required to ensure that PLOs are being met and that software used in teaching and projects is relevant within industry. This is something that could be done in consultation with the PAC.

Facilities & Services Recommendation #4: Though preparing students for graduate school is not necessarily the primary goal of the PMT program (Self-Study, page 7), it is clear there is a high-level of faculty support needed for students who choose to pursue that path. This includes a general understanding with other institutions regarding additional upper-level undergraduate course requirements prior to full admission to graduate programs at those schools. The PMT program should work to formalize agreements with institutions in conjunction with KPU leadership and FSH advising services to provide a concrete framework for pursuing graduate studies. The ERT recommends that the PMT continue to work with advising services and KPU leadership to streamline some of these pathways so that there is more support for students and faculty.

CONCLUDING COMMENTS

The members of this ERT greatly enjoyed the opportunity to learn more about the PMT program at KPU. Overall, we were impressed by the strength and quality of the program, the enthusiasm of the students and alumni, and the general positive and supportive atmosphere we experienced during every meeting.

APPENDIX 1: EXTERNAL REVIEW SITE VISIT AGENDA

Kwantlen Polytechnic University

Physics for Modern Technology
External Review Hybrid (Online/In-Person) Site Visit Agenda

November 30 & December 1, 2022
Online Via Microsoft Teams
In-Person in Room 3450B on KPU Richmond Campus

Thanks to External Reviewers:
Jeffrey McGuirk, SFU
Lindsay Norris, KPU
Matthew Gullen, D-Wave

Day 1: November 30, 2022

9:00 - 9:50	Introductions and First Meeting with Program Chair
9:50 - 10:00	Break
10:00 – 10:30	Tour of the Program's Facilities
10:30 - 10:40	Break
10:40 - 11:30	Meet with University Services Panel (Library Services/ Faculty Advising)
11:30 - 11:40	Break
11:40 - 12:40	Meet with Faculty Members
12:40 - 12:50	Break
12:50 – 13:30	Meet with Dean/Associate Dean

Day 2: December 1, 2022

9:00 – 10:00	Meet with Alumni/Program Advisory ERT
10:00 - 10:10	Break
10:10 - 11:10	Meet with Students
11:10 - 11:20	Break
11:20 - 12:00	Final Meeting with Program Chair
12:00 - 12:10	Break
12:10 - 12:40	External Review Team meets to discuss findings and coordinate their review.

*Note that listed times are in Pacific Standard Time.